



Achieving a Cost Effective and Reliable Electricity Supply for Australia

Dr Robert Barr AM

Electric Power Consulting Pty Ltd

**Presentation to the Australian Institute of Energy
Sydney**

16 October 2018



Presentation Outline

- Will provide modelling of the NEM to show the customer impacts of changing our generation mix.
- Look closely at six (6) generation mix options.
- Customers need us to put forward options to governments that will deliver for Australia.
- AIE, EESA, ATSE and Engineers Australia have key roles to play.

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Torrens Island



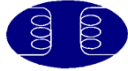
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Wind S.A.



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Eraring Power Station



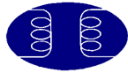
Electric Power Consulting Pty Ltd •5



Yallourn Power Station



Electric Power Consulting Pty Ltd •6



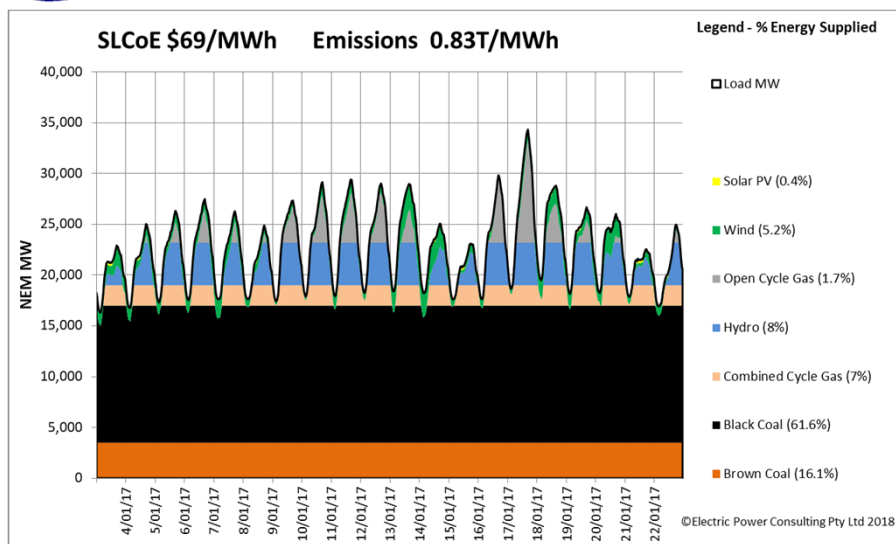
The EPC NEM Generation Mix Model

- Built by Electric Power Consulting Pty Ltd.
- Designed to explain some basic principles of power system engineering:
 - analysis.
 - customer education.
 - provides a framework for making sensible informed choices.
- Simultaneously incorporates both power system constraints and economic dispatch constraints:
 - generation mix must be capable of continuously supplying customer demand on a second by second basis; and
 - generation merit order dispatch in order of lowest marginal cost.
- More information and disclaimer at <https://epc.com.au>

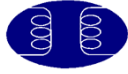
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How Does the EPC Model Work?



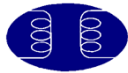
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What Makes the EPC NEM Different to other Models?

- The EPC model focuses on “Whole of System” costs – not just individual generator costs.
- The EPC model incorporates the extra costs of transmission needed to connect geographically dispersed generation and pump storage systems.
- NEM Model identifies generation mixes that are technically not feasible:
 - generation mixes that have insufficient MW capacity to meet customer needs when there is little or no wind or solar PV output.
 - when base load coal and CCG generators are forced into uneconomic operations:
 - at levels below their minimum output capabilities.
 - at ramp rates above their capabilities.

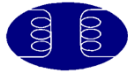
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EPC NEM Model Assumptions

- No transmission constraints.
- No network losses.
- Ancillary services costs are neglected.
- Efficiency of fossil fuel generators is constant at all output levels.
- Generator costs, generally based on AEMO Integrated Survey Plan for the year 2018.
- Nuclear cost data gathered from South Korea 2018 study tour.
- LCoE discount rate 6% p.a..

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EPC NEM Model Assumptions

- Actual diversified wind & solar PV generation patterns + actual NEM customer load is used (3/1/2017 to 3/1/2018 from AEMO).
- Storage strategy:
 - maximise storage levels at all times.
 - used only for supplying peak demands.
- Provides warnings only of unsustainable base load generator variations.
- Transmission services costs vary in proportion to the total nameplate MW capacity of the generation sources.
- Calculated emissions based on:
 - combustion.
 - power station construction.
 - mining and fugitive emissions (0.5%).

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Electric Power Consulting Pty Ltd Power System Generation Mix Model Output

Scenario: Base Case 1 - Existing NEM approximation

Version 1.6 Run Number 79

| Generation Type | Installed MW | Net Available MW | Storage Days | % of Load Energy Supplied | Levelised Cost of Energy (LCOE) \$/MWh | Contribution to System Levelised Cost of Energy (SLCOE) \$/MWh | Carbon Intensity T/MWh | Contribution to System Carbon Intensity T/MWh |
|---|--------------|------------------|--------------|------------------------------|--|--|---------------------------------|---|
| Battery Storage | 100 | 100 | 0.06 | 0.0% | | \$0.13 | | |
| Solar PV | 323 | 323 | | 0.4% | \$117.32 | \$0.48 | 0.034 | 0.00 |
| Wind | 3,500 | 3,500 | | 5.2% | \$93.08 | \$4.80 | 0.012 | 0.00 |
| Open Cycle Gas | 10,660 | 10,500 | | 1.7% | \$348.91 | \$6.02 | 0.606 | 0.01 |
| Hydro | 4,200 | 4,200 | | 8.0% | \$80.78 | \$6.50 | 0.024 | 0.00 |
| Combined Cycle Gas | 2,116 | 2,000 | | 7.0% | \$92.23 | \$6.43 | 0.415 | 0.03 |
| Black Coal Supercritical | 14,286 | 13,500 | | 61.6% | \$50.90 | \$31.33 | 0.9635 | 0.59 |
| Brown Coal Supercritical | 3,704 | 3,500 | | 16.1% | \$56.71 | \$9.15 | 1.228 | 0.20 |
| Total | 38,889 | 37,623 | | Energy storage decrease 0.0% | | | | |
| | | | | Total..... | | | | 100.0% |
| Subtotal Generation..... | | | | | \$64.83 | /MWh | Total..... | 0.83 |
| Extra Transmission.... | | | | | \$4.04 | /MWh | CO2 Emission Abatement Analysis | |
| System Levelised Cost of Energy | | | | | \$68.87 | /MWh | | |
| Base Transmission..... | | | | | \$42.25 | /MWh | Reference | \$69.20/MWh |
| Delivered Cost of Energy for Transmission Customers | | | | | \$111.12 | /MWh | Base level.... | 0.82 T/MWh |
| Distribution.... | | | | | \$100.00 | /MWh | Cost of Abatement N/A/Tonne | |
| Delivered Cost of Energy for small LV Customers | | | | | \$211.12 | /MWh | | |

User input

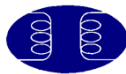
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User input

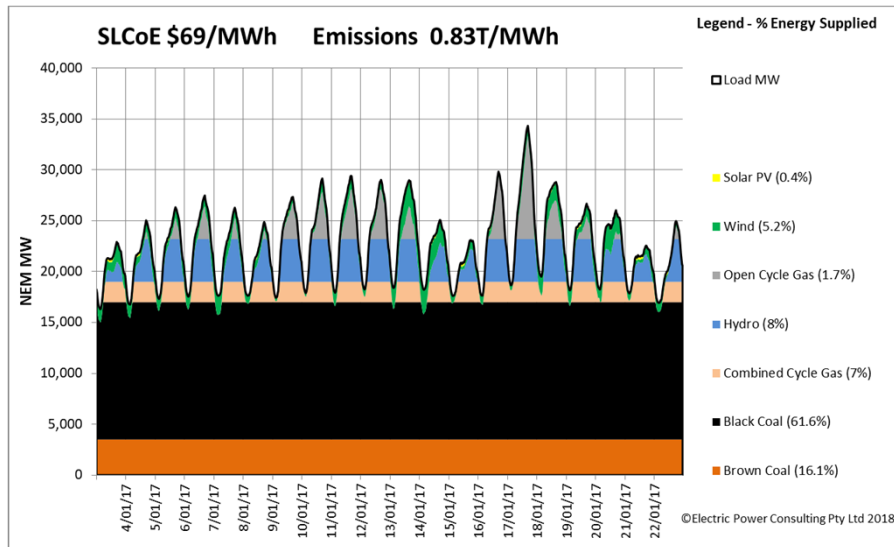
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User input

Key outputs



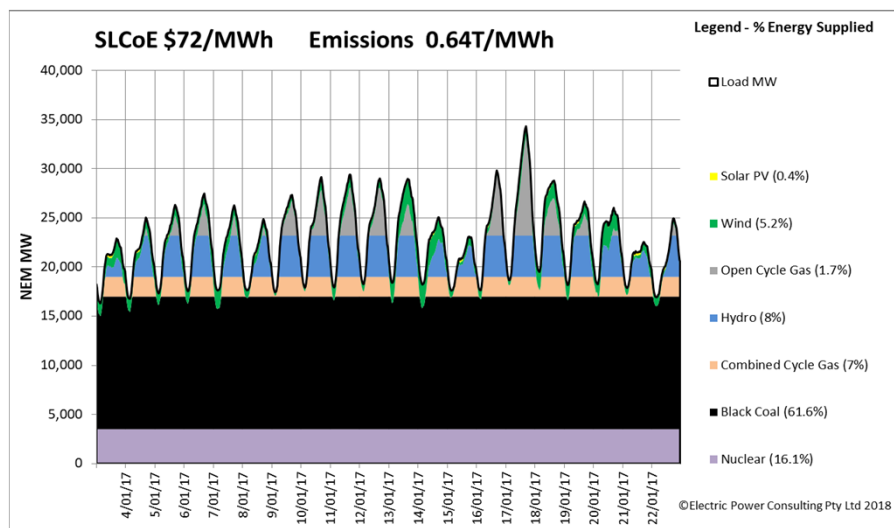
Base Case 1 - Existing NEM approximation



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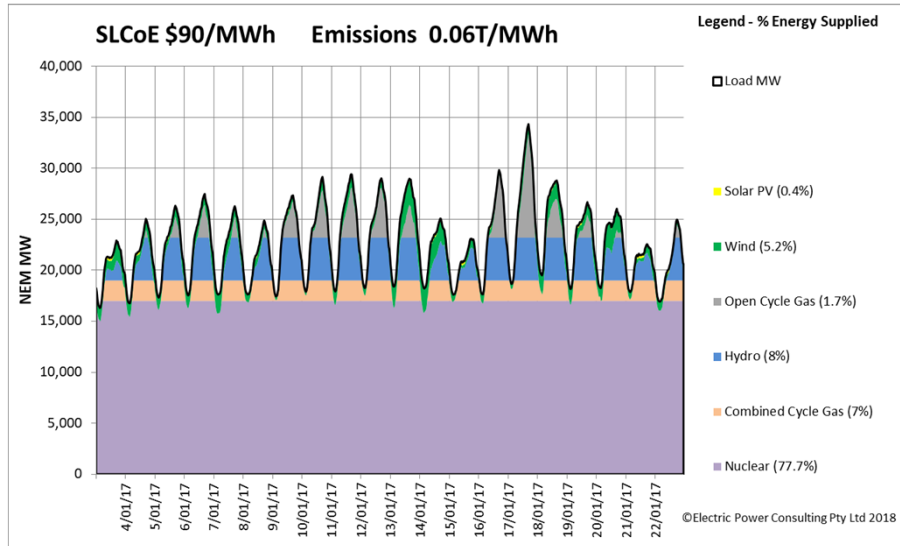
Case 2 - Replace Brown Coal Generation with Nuclear



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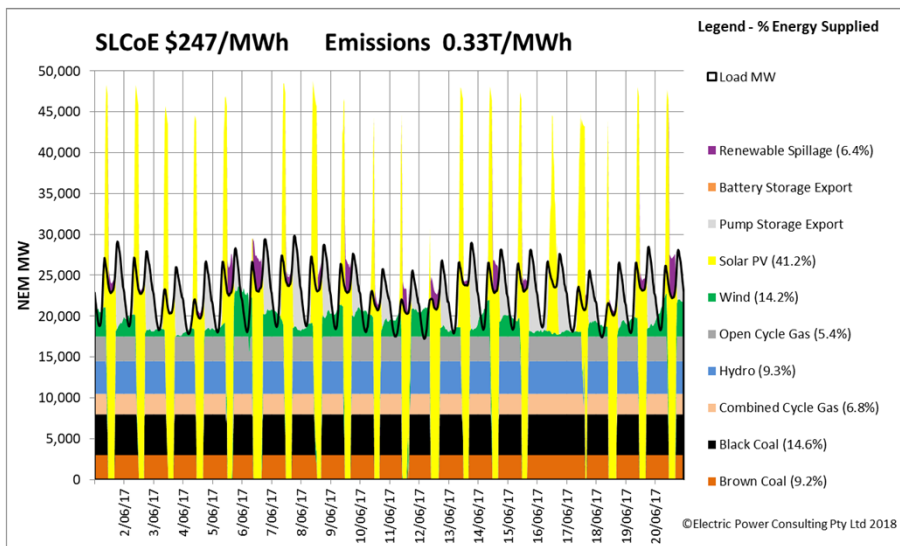
Case 3 - Replace all Coal Generation with Nuclear



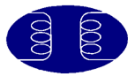
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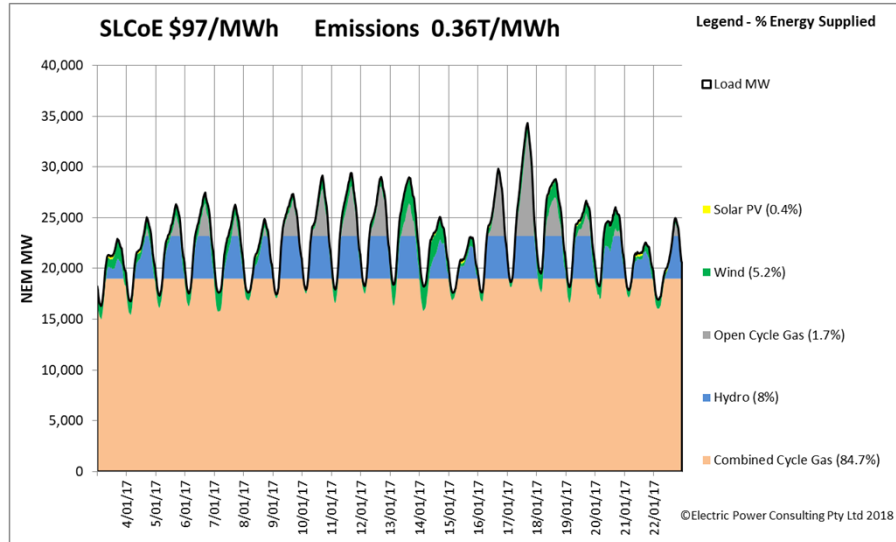
Case 4 - AEMO Neutral case Fig. 9 - 2040 approx.- ISP 2018



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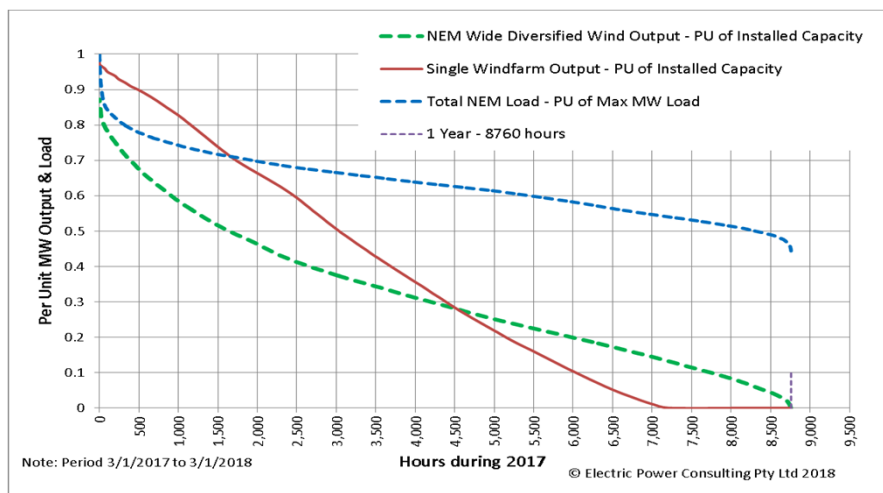
Case 5 - Replace all Coal Generation with Combined Cycle Gas



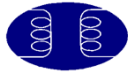
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NEM Wide Load Duration & Wind Output Curves 2017



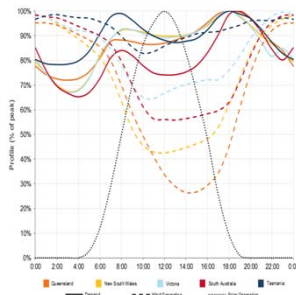
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AEMO ISP – Use of “Averages”

AEMO Consultation Paper

Figure 6 Average daily profile of wind farm output per region (NEM time)



EESA Submission

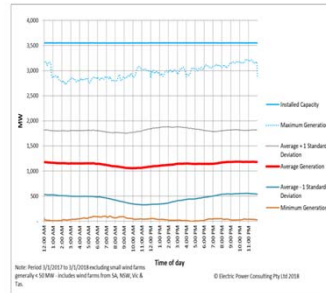
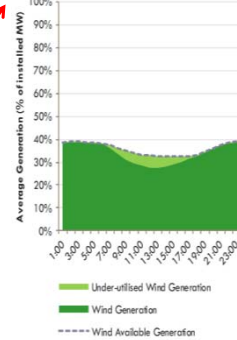


Figure 4 - NEM Wide Aggregated Wind Farm by Time of Day

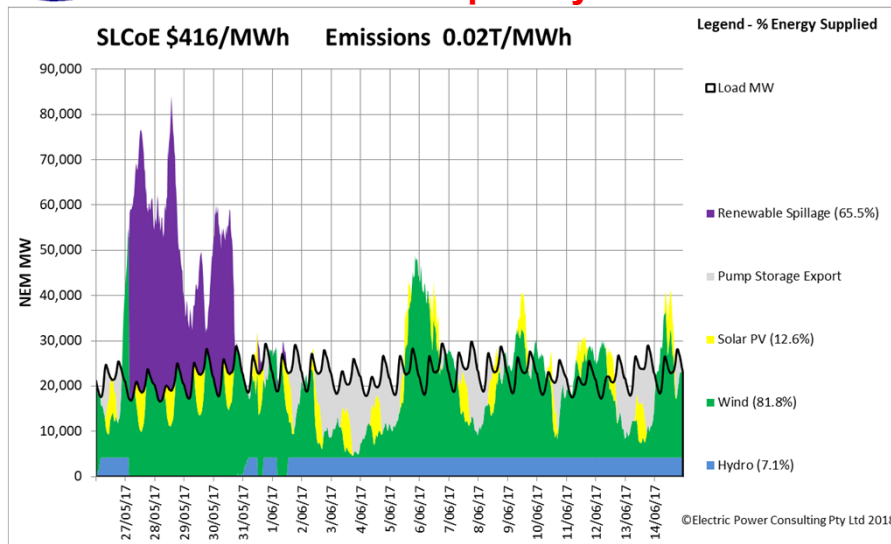
AEMO ISP



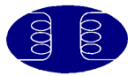
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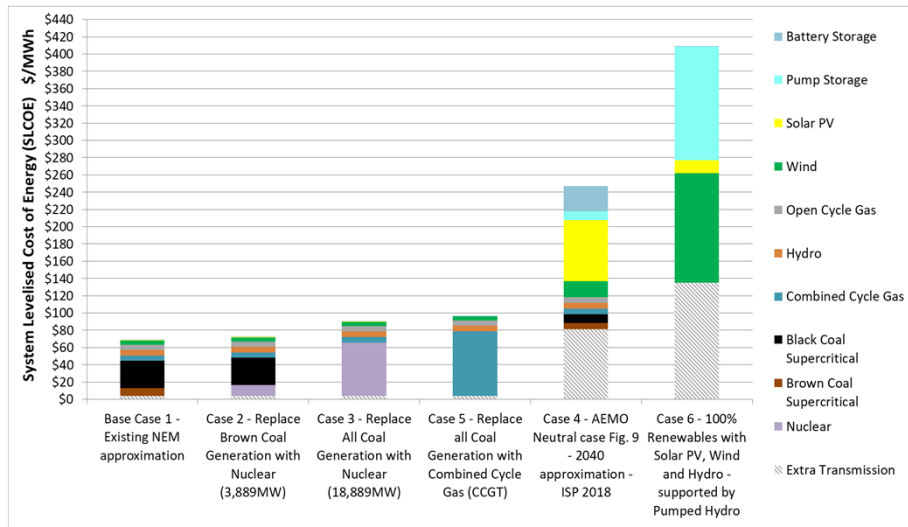
Case 6 - 100% Renewables supported by Pumped Hydro



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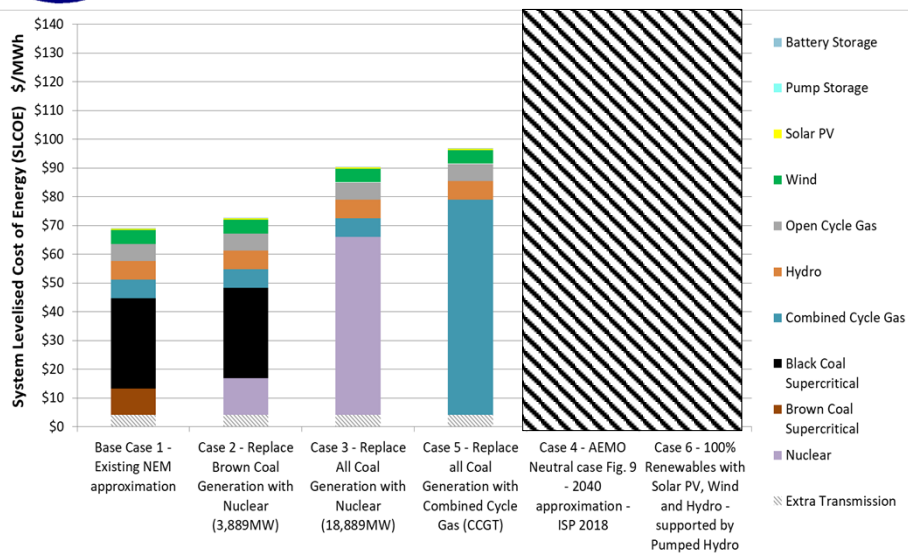
Model Results - SLCOE



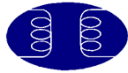
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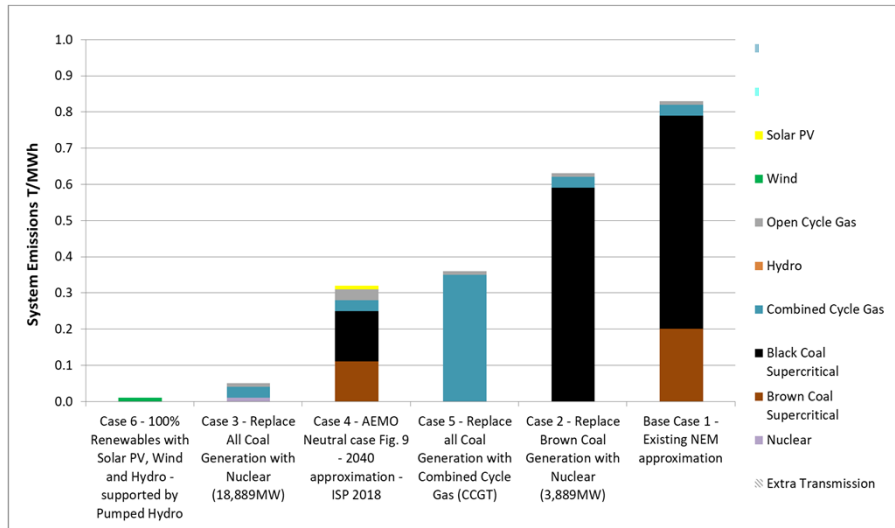
Model Results - SLCOE



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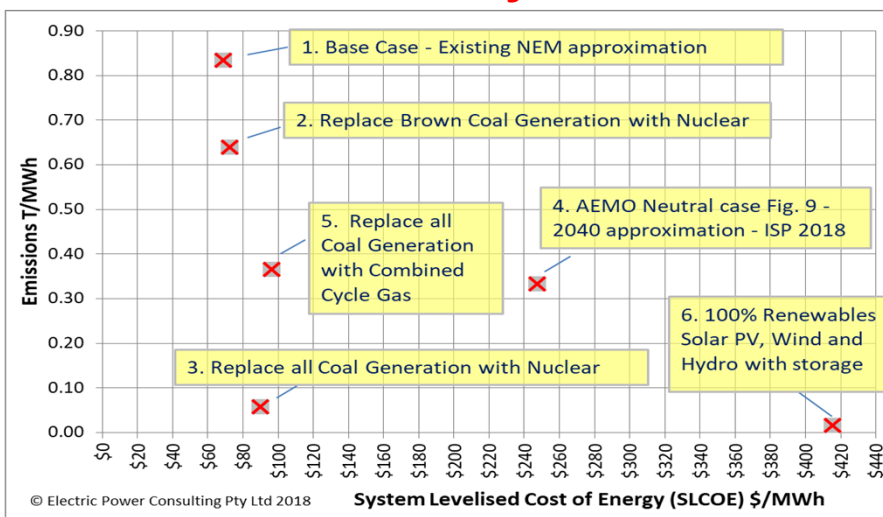
Model Results – CO₂ Emissions



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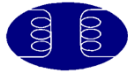
Summary of Results The Policy Dilemma



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System Levelised Cost of Energy (SLCOE) \$/MWh

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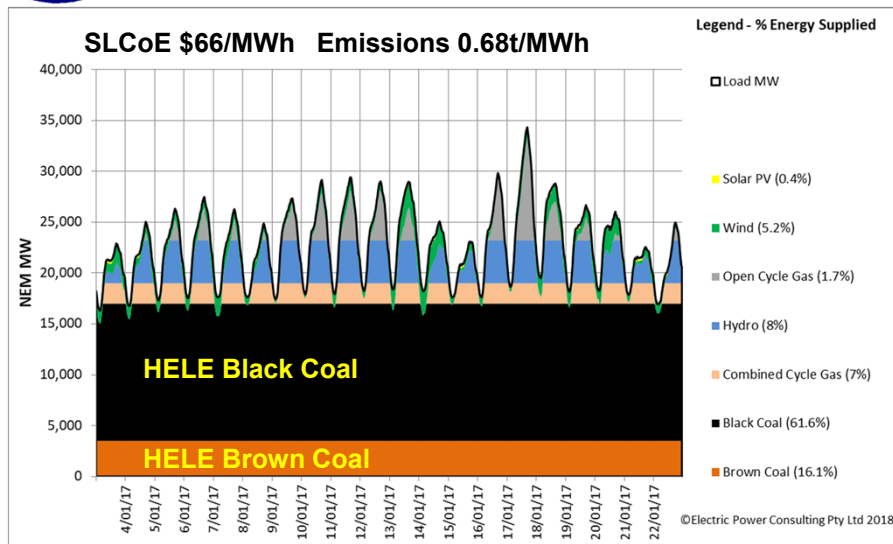
AIE Request for Generation Mix Options to Model

- Request from Denis Cooke
 - Replace Existing Black and Brown Coal Generation with High Efficiency Low Emissions Black and Brown Coal Generation

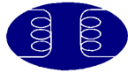
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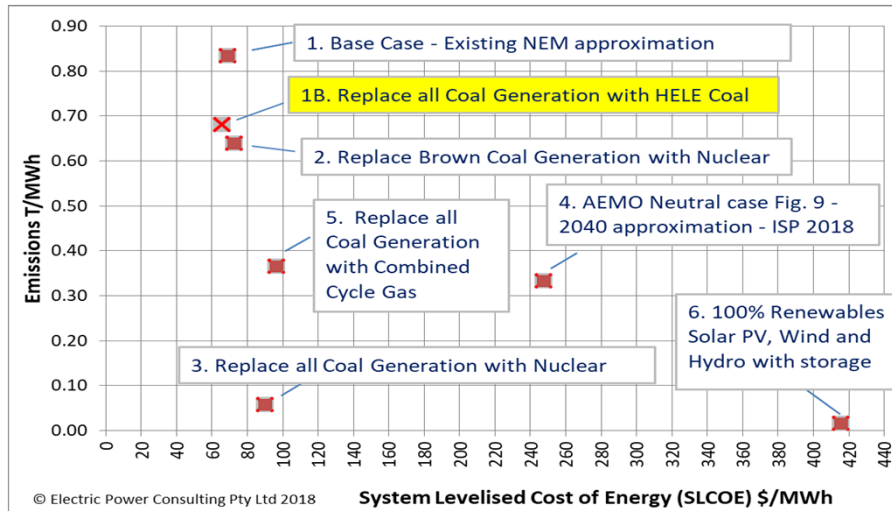
Case 1B - HELE Coal



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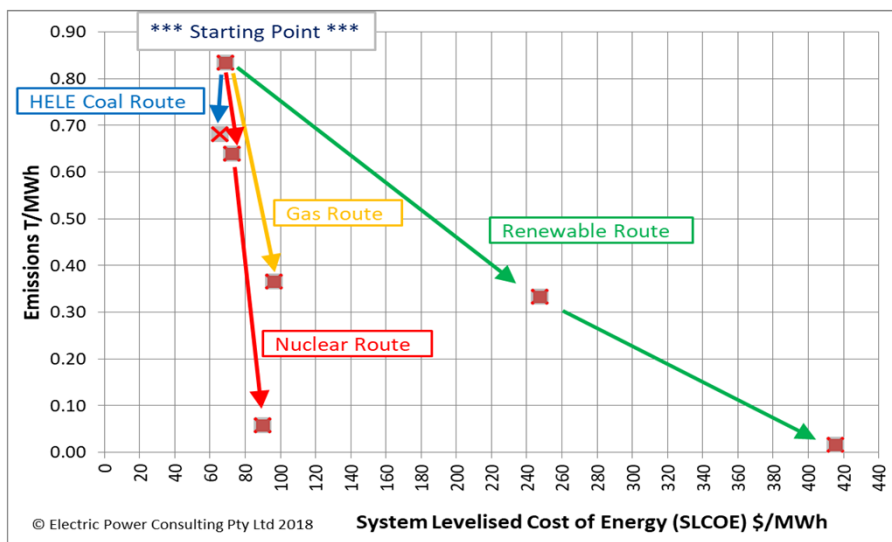
Case 1B HELE Coal



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Summary of Generation Mix Options



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Conclusions 1

- Adding more Intermittent Renewable Generation into the NEM will drive up the System Levelised Cost of Energy (SLCoE).
- Need to sum the costs of;
 - direct wind and solar PV.
 - firming costs – OCG, pumped storage and batteries.
 - extra transmission costs.

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Conclusions 2

- Coal - lowest cost option, Australia could move toward High Efficiency Low Emissions (HELE) coal plants.
- Nuclear – the most cost effective option for large scale emission reduction.
- Combined Cycle Gas – modest cost & modest emissions reduction.
- Part Renewables – high cost & modest emissions.
- 100% renewables – very high cost & lowest emissions.

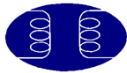
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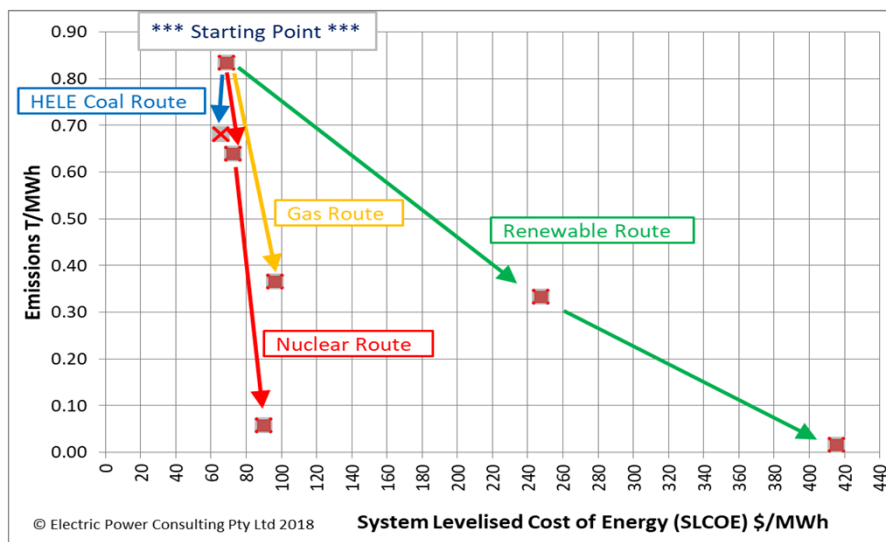
Conclusions The Way Forward

- Australia has many electricity generation options.
- No one technology will provide the desired outcome.
- Competition between alternative technologies is vital.
- To deliver for customers we need:
 - removal of all subsidies.
 - markets that value both MWh energy and MW capacity.
 - a truly technology neutral approach.
 - removal of the legislative ban on nuclear energy.

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Questions



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